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(54) A method of stimulating a well

(57) The invention relates to a method of stimulating a drilled well for use in the production of oil or gas from a formation, wherein acid or the like aggressive liquid is supplied for decomposing material (51) on the surface of a well bore by use of a tubing (70) arranged within the well bore while forming a space (57) between the tubing (70) and the surface of the well bore, wherein said supplied liquid is discharged to said space (57) through openings (72) formed in the wall of the tubing (70) in the longitudinal expanse of the tubing (70) for influencing the material (51) on the surface of the well bore. The invention is characterised in

- that the that the well bore (50) is established;
- that a first portion of the well bore (50) thus formed is provided with a reservoir liner (40) for the production of oil or gas;
- that the tubing (70) is introduced into the well bore (50) for extending at least into a second portion (S) of the well bore (50) to the profoundly situated end (55) of the well bore.

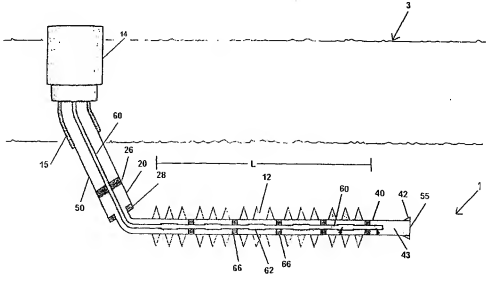

Fig. 1

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Description

[0001] The present invention relates to a method of stimulating a drilled well for use in the production of oil or gas from a formation, wherein acid or the like aggressive or reactive liquid is supplied to decompose material deposited on the wall of the well bore by use of a tubing arranged within the well bore while forming a space between the tubing and the well bore surface, wherein said supplied liquid is discharged into said space through openings configured in the wall of the tubing in the longitudinal expanse of the tubing for influencing the material on the surface of the well bore. The invention also relates to a drilled well with apparatus for exercising the method.

[0002] The present description includes both a drilled production well intended for the actual production of oil or gas, or it may be a drilled well intended for injection of water into the formation with a view to displacing oil or gas in a direction towards a drilled production well.

[0003] The journal 'Oilfield Review', Vol 2, No 3, teaches how, before the production of oil and gas can be initiated, it is necessary to stimulate a well bore by pumping down acid that decomposes the compacted layer of drilling mud on the wall of the well bore and a part of the formation. The acid is conveyed into the well bore by means of a supply pipe with a nozzle head that is, while acid is being pumped down, withdrawn slowly from the bottom of the well bore. Once the drilling mud has been decomposed, a production tubing is inserted into the well bore, and the production can be initiated. The described nozzle head, however, is expensive and the process is labour-intensive and delays the time of onset of production.

[0004] A method of the kind described in the preamble to claim 1 is described in the journal *'Society of Petroleum Engineers'* having the identification code SPE 35 641.

[0005] The invention aims to remedy the problems and limitations that are associated with the conventional methods of stimulating a drilled well for use in the production of oil or gas from a formation, wherein the invention enables production of oil or gas from areas that are located far away from the well head via one and the same drilled well. This is obtained as featured in the characterising part of claim 1 whereby the tubing with the openings is used in connection with a conventional drilled well with a reservoir liner that is perforated with a view to production of oil or gas through these perforations. Preferably production is carried out via a production tubing inserted into the reservoir liner.

[0006] On the one hand, conventional use of such reservoir liners is associated with a large number of production advantages, but the maximum introduction depth of gaskets, etc., into the reservoir liner simultaneously limits the expanse of the area from which production is possible. By the method according to the invention, it is surprisingly possible to produce from distant areas following an initial stimulation, the tubing being introduced into the well bore in extension of the reservoir liner.

[0007] As featured in claims 5 and 6 the openings can preferably be arranged in such a manner that substantially the same amount of the liquid is discharged per length unit of the tubing through the openings. The variation in the discharged amount of liquid per longitudinal unit preferably constitutes maximally 10 percent.

[0008] The openings in the tubing can, in accordance with claim 7, be formed in the wall of the tubing - either prior to or after mounting of the tubing in accordance with a predetermined pattern that yields a desired discharge of the liquid.

[0009] According to a preferred embodiment the tubing is left behind in the drilled well following finished stimulation, and oil or gas is produced via the tubing. Hereby considerable process economies are obtained.

[0010] The invention also relates to a drilled oil or gas well with the described tubing arranged in extension of a reservoir liner through which oil or gas is produced and with a space between the tubing and the well bore.

[0011] The invention will now be described in further detail with reference to the preferred embodiment shown in the drawing. In the drawing:

Figure 1 is a not-to-scale sketch of a conventional drilled oil well; and

Figure 2 is an acid-stimulation tubing according to the invention.

[0012] Now, Figure 1 shows and example of how to exercise the invention in connection with a conventional drilled oil or gas production well that extends, at its end, horizontally into an oil- or gas-containing reservoir 1. The well bore 50 as such is established by drilling with bore heads having decreasing operation diameter. Generally the drilling process gives rise to the formation of a compacted layer of drilling mud on the wall or the surface of the well bore 50.

[0013] In the first portion of the well bore 50 near the surface or the seabed 3, a liner 15 is introduced that is subsequently provided with an enclosing cement shell that is cast in the space between the outside of the liner 15 and the wall of the well bore 50. The cement shell serves ia to brace the well bore.

[0014] In the subsequent portion of the well bore that is usually produced by use of a drill head with another and smaller diameter, a subsequent liner 20 is introduced whose outer diameter corresponds approximately to said smaller diameter. Such next liner 20 extends from the surface 3 and to a depth of eg 4000 feet. Now cement is pumped down that forms a shell between the liner 20 on the one side and the wall of the well bore 50 and the liner 15, respectively, on the other side.

[0015] The described procedure is repeated a number of times until the drill head has reached the de-

sired reservoir section. At this point in time, a so-called reservoir liner 40 is introduced that has a typical diameter of 7", cement being again pumped down to form a shell between the outside of the reservoir liner 40 and the wall of the well bore 50 in the reservoir 1. The reservoir liner 40 has a typical production length L of 8000 feet, over which length oil or gas is produced from the reservoir 1.

[0016] The advancement as such of oil or gas from the reservoir 1 to the surface 3 is accomplished via a production tubing 60 that is conveyed down through the reservoir liner 40 and onwards to the end 55 of the well bore 50. Prior to introduction of the production tubing 60, the reservoir liner 40 and its enclosing cement shell must be perforated locally to create passages between the reservoir 1 and the production tubing 60. Also a so-called fracturing 12 is often performed, or a so-called acid-matrix treatment, of the formation 1 opposite the perforations formed in the reservoir liner 40 to increase the discharge of oil or gas from the reservoir 1.

[0017] Usually, the production tubing 60 carries a number of external peripheral gaskets 66 and has openable gates 62 mounted in the wall of the production tubing 60. Hereby it is possible to produce oil or gas from selected areas of the reservoir 1. The production length L is typically delimited by the maximal distance with which the production tubing lends itself for being introduced into the reservoir lining 40. The friction between the inside of the reservoir liner 40 and the outside of the production tubing 60 with the gaskets 66 thus sets an upper limit to how far into a horizontal well bore it is possible to introduce the production tubing 60.

[0018] Figure 2 shows the present invention used in conjunction with a conventional drilled well as shown in Figure 1. To exercise the invention the well bore 50 has an end area S that extends within the reservoir 1 past the end 42 of the reservoir liner 40, ie further to the right in Figure 1. Thus the well bore 50 is considerably longer than the possible depth of introduction of the production tubing 60. In the end area S, the well bore 50 can also have a diameter that is smaller than the diameter of the reservoir liner 40, eg a diameter of 5". The end area S can have an expanse of eg up to 10,000 feet.

[0019] It will be understood that in one embodiment of the invention the reservoir tubing 40 is first introduced in the desired depth and then the reservoir liner 40 is provided with an enclosing cement shell 45. Then drilling is continued to provide the end area S of the well bore 50.

[0020] Following provision of the end area S, the end area S can optionally be provided with a not shown thin-walled lining, known within the trade as a "slotted liner", and having a large number of evenly distributed, through-going openings. Such slotted liner is shown in the above-referenced article and will, in the majority of cases, give rise to a large area of the surface 51 of the well bore 50 continuing to be exposed.

[0021] Now, according to the invention, a stimulation tubing 70 is introduced into the end area S by means of conventional introduction equipment, and the production tubing 60 is introduced into the reservoir liner 40. The tubing 70 that has a first open end 73 - to which acid is supplied via the production tubing 60 and which is preferably closed at the opposite end 74 - is located to extend approximately from the end 42 of the reservoir liner to the end 55 of the well bore 50. The first end 73 of the tubing 70 is preferably attached to the inner wall of the reservoir liner 40 by means of a conventional gasket 48. The tubing 70 has a diameter that is smaller than the diameter of the well bore 50, whereby - between the outer surface of the tubing 70 and the exposed surface of the well bore 50 or a slotted liner, if any - a space 57 will appear. Obviously, Figure 2 features an ideal state in which the space 70 is annular. In practice the tubing 70 will have a slightly curved forward course interiorly of the area S and will abut on the surface of the well bore 50 along a modest part of the periphery of the tubing 70.

[0022] The stimulation tubing 70 is, in the embodiment shown, provided with a number of pre-formed openings 72 that form flow passages between the interior of the tubing 70 and the annular space 57. The openings 72 have a shape and location that comply with particular, pre-defined specifications, as will be described in further detail below.

[0023] By the reference numeral 51 Figure 2 also shows a compacted layer of drilling mud that must, as described above, be decomposed by supply of acid to the end area S before production of oil or gas can be initiated. By the invention, it is sought to supply the acid to this area S without use of a movable nozzle head that is conveyed upwards from the end 55 of the well bore, as the fixed tubing 70 is used to advance the acid. Use of the described stimulation tubing 70 makes it possible, to a wide extent, to ensure homogenous decomposition of the drilling mud 51 and the most proximate part of the formation in the entire end area S.

[0024] According to one embodiment, the invention is based on the discovery that in order to be able to decompose all of the drilling mud 51 and the most proximate portion of the formation in the entire end area S and thus ensure that production is possible from the entire formation, acid should be supplied to the entire length of the end area S on the same time. According to one embodiment of the invention it is possible, from the tubing 70, to discharge the same or at least substantially the same amount of acid per length unit. It has been found that it is hereby avoided that the drilling mud is decomposed relatively early in limited sections of the end area S. Such localised decomposition of the drilling mud 51, eg exclusively in the shown area S2, may entail a violent, localised outflow of the acid to the reservoir 1. In case acid is merely supplied to a limited portion of the en area S, eg at the area 43, it may thus occur that the acid will only to a limited extent or at a very low concentration or not at all reach the remaining portions of the end area S.

[0025] However, the invention also takes into account other needs. For instance, openings can be omitted in certain parts of the tubing 70, including areas of the formation in which it is possible to an insignificant degree only to produce oil or gas.

[0026] As a starting point, when the openings 72 are to be positioned and configured, the pressure conditions within the tubing 70 are taken into account. In this manner it is possible, for instance, without further ado to ensure that the outflow of acid from the tubing 70 per length unit of the tubing 70 is the same - or approximately the same - within a tolerance of preferably maximally about 10%. Such outflow to the space 57 can be achieved by use of openings 72 having the same diameter but being located at a decreasing distance from each other in a direction towards the end 74, as is shown in Figure 2. Alternatively, it is possible to use openings 72 arranged at the same mutual distance, but with an increasing diameter in a direction towards the end 72 of the tubing 70. It is also possible to use an increasing number of openings per length unit of the tubing 70 in a direction towards the end 74, or alternatively to provide the openings with suitably set pressure-loss regulating means. Thus, the openings 72 need merely be arranged or configured such that - with due regard to parameters such as inflow pressure at the end 73 of the tubing 70, pressure loss along the tubing 70, pressure variations within the space 57, and the supplied amount of acid - the desired outflow per length unit of the tubing 70 is provided, eg an outflow that is - to the widest extent possible - the same along the tubing 70. Hereby a desired treatment of the wall of the well bore 50 is ensured.

[0027] Said parameters can be defined at an early stage, and the final configuration of the tubing 70 can thus be determined already before the drilling is initiated. It is noted that the tubing 70 will - in accordance with the invention - usually be composed of a number of short tubular members.

[0028] It has also been found to be possible to use the tubing 70 in connection with the production as such of oil or gas from the reservoir 1. According to the invention the tubing 70 is preferably left behind in the end area S of the well bore 50 following finished acid stimulation, and thereby the tubing serves as a production tubing, oil flowing from the annular space 57 and into the tubing 70 via the openings 72. The tubing 70 can, if desired, be connected directly to the production tubing 60 in the area 43 that may optionally also serve to supply the acid to the tubing 70.

[0029] Obviously, it is also possible to remove the tubing 70 following the acid stimulation operation, but in principle it would involve a redundant working procedure. It should be noted that, if desired, the tubing can be dimensioned with such strength that it is an option that it can stabilise the well bore 50 in the event that the formation is weakened during the oil production. It is also obvious that for the manufacture of the tubing 70 a material should be selected that is resistant to the acid used.

[0030] The invention is not limited to the described exemplary embodiment, but may also be useful for the stimulation of a drilled well intended for the injection of water or corresponding liquid into the formation with a view to displacing oil or gas in a direction towards a drilled production well.

Claims

1. A method of stimulating a drilled well for use in the production of oil or gas from a formation, wherein acid or the like aggressive liquid is introduced for decomposing material (51) on the surface of a well bore by use of a tubing (70) arranged within the well bore while forming a space (57) between the tubing (70) and the surface of the well bore, said supplied liquid being discharged to said space (57) through openings (72) formed in the wall of the tubing (70) in the longitudinal expanse of the tubing (70) for influencing the material (51) on the surface of the well bore, **characterised in**

   - **that** the well bore (50) is established;
   - **that** a first portion of the well bore (50) thus formed is provided with a reservoir liner (40) for the production of oil or gas;
   - **that** the tubing (70) is introduced into the well bore (50) for extending at least into a second portion (S) of the well bore (50) to the profoundly situated end (55) of the well bore (50).

2. A method according to the preceding claim, **characterised in that** said second portion (S) of the well bore (50) extends at least partially inclined or horizontally.

3. A method according to any one of the preceding claims, **characterised in**

   - **that** said reservoir liner (40) is perforated following introduction of the tubing (70); and
   - **that** production is performed through said perforations.

4. A method according to any one of the preceding claims, **characterised in that** a production tubing (60) is introduced into the well bore (50).

5. A method according to any one of the preceding claims, **characterised in that** substantially the same amount of said liquid is discharged per unit of length of the tubing (70) through said openings (72).

6. A method according to the preceding claim, **characterised in that** the discharged amount per length unit of a portion of the tubing (70) differs less than

10 percent from the discharged amount of liquid per length unit in a second portion of the tubing (70).

7. A method according to any one of the preceding claims, **characterised in that** the openings (72) in the tubing (70) were made prior to the introduction into the well bore (50) of the tubing (72).

8. A method according to any one of the preceding claims, **characterised in**

- **that** the tubing (70) is left behind following finished stimulation; and
- **that** oil and/or gas is produced via the tubing (70).

9. A method according to any one of the preceding claims, **characterised in that** the tubing (70) is attached to one of the liners (15, 20, 40) by means of an enclosing gasket (48).

10. A drilled well for use in the production of oil or gas from a formation having a first portion comprising a perforated reservoir liner (40) for the production of oil or gas, **characaterised in**

- **that** a second section (S) of the drilled well extends in extension of said first portion of the drilled well (50) from the end (42) of the reservoir liner (40);
- **that**, in the second portion (S) of the well bore, a tubing (70) extends that has openings (72) arranged in the longitudinal expanse of the tubing (70) wherein said openings (72) - with due regard to a liquid supply pressure - allow discharge of a desired distribution of liquid supplied to the tubing (70) at the one end (73) of the tubing (70); and
- **that** a longitudinally extending space (57) appears between the tubing (72) and the wall of the well bore (50).

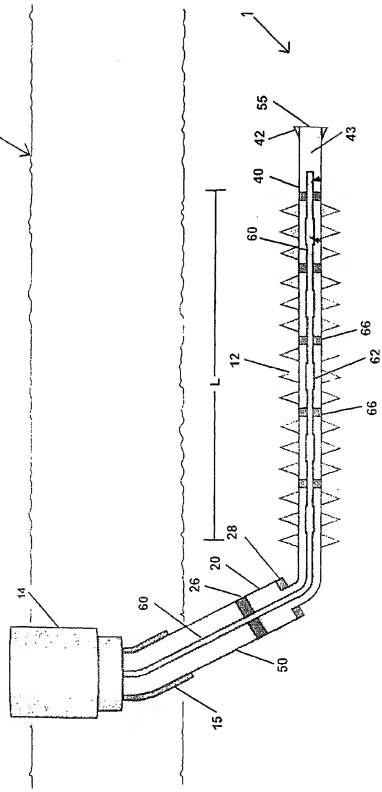

Fig. 1

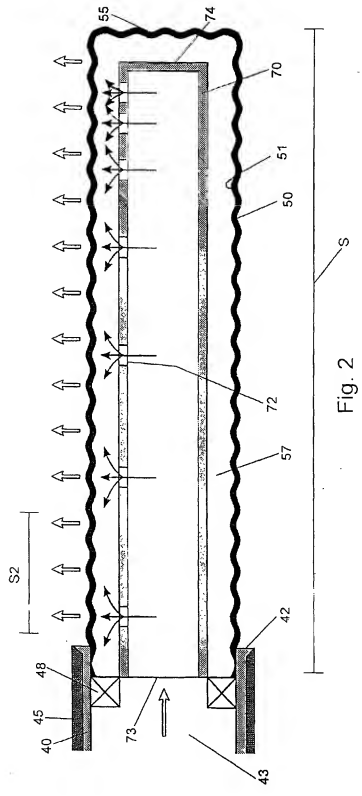

Fig. 2